ASPECTS OF THE ROCKNEST FORMATION, ASIAK THRUST-FOLD BELT, WOPMAY OROGEN, DISTRICT OF MACKENZIE

Project 810021

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Abstract

Field study of the Rocknest Formation during 1981 and 1982, and laboratory study during the fall of 1982 has produced several interesting findings which are summarized in this report. Topics are: 1) subdivision of Rocknest Formation into ten informal members, 2) Rocknest shelf cyclicity and paleogeography, 3) shelf-to-slope transitions, 4) paleoclimate, and 5) evidence of possible microbial remnants in stromatolite bioherms of the Odjick/Rocknest transition beds. Future fieldwork is outlined.

Résumé

Le rapport présente les résultats intéressants d'études de la formation de Rocknest entreprises sur le terrain en 1981 et 1982, et en laboratoire en automne 1982. Les sujets comprennent 1) la subdivision en dix niveaux officieux de la formation de Rocknest, 2) la cyclicité et la paléogéographie du plateau de Rocknest, 3) les transitions de plateau à talus, 4) le paléoclimat et 5) des preuves de la présence possible de restes de microbes dans les biohermes de stromatolites des couches de transition d'Odjick et de Rocknest. Un aperçu des travaux sur le terrain à venir est présenté.

Introduction

The Rocknest Formation is a 1.9 Ga carbonate terrace that formed on a passive continental margin, exposed in the Asiak Thrust-Fold Belt and autochthonous basins (Fig. 10.1) of Wopmay Orogen (Hoffman, 1980). In 1981, a three-year project was initiated to investigate the evolution of the Rocknest carbonate shelf and document: 1) shelf-to-basin transitions, 2) slope, shelf-edge, and cyclic shelf-interior facies, 3) stromatolite types present and environmental and/or biological controls on their distribution, and 4) similarities and differences between the Rocknest and Phanerozoic carbonate shelf sequences. This study is part of a broader project designed to study the externides of Wopmay Orogen (Hoffman et al., 1983).

In 1982, sections were measured at the southern and northern ends of the thrust-fold belt, and at present a total of 28 sections have been measured in the Redrock Lake (86 G), Point Lake (86 H), Takijuq Lake (86 I), Hepburn Lake (86 J), Coppermine (86 O), and Kikerk Lake (86 P) map areas. The information in this report is based on fieldwork completed during 1981 and 1982, and laboratory work completed during the fall of 1982.

Subdivision of Rocknest Formation into Informal Members

The Rocknest shelf-interior facies comprises inter-stratified argillaceous dololutite and stromatolitic dolomite arranged in cyclic, shoaling-upward sequences 1-10 m thick. The cycles can be grouped into distinct sets, or members, 10-450 m thick, based on variations in the relative proportion of argillaceous dololutite to stromatolitic dolomite.

The Rocknest Formation was previously subdivided into five informal members (Grotzinger, 1982) that were used as stratigraphic markers for 1:50 000 scale mapping of selected areas within Asiak Thrust-Fold Belt during the 1981 field season (Tirrul, 1982). However, recent 1:50 000 scale mapping during the 1982 field season (Hoffman et al., 1983) has shown that a more detailed stratigraphic breakdown is required to best show variations in structural level and style. It is proposed here that the Rocknest Formation be subdivided into ten informal members according to key beds, and variations in the ratio of argillaceous dololutite to stromatolitic dolomite in successive groups of shoaling-upward cycles.

Figure 10.2 illustrates the ten informal members of the Rocknest Formation in Asiak Thrust-Fold Belt. These members are shelf-interior facies and occur in the autochthon and all thrust panels which expose the Rocknest Formation except for the "X" thrust sheet (Fig. 10.1) which exposes shelf-edge and slope facies. Correlations between shelf-interior sections and shelf-edge sections are obscured by abrupt facies changes across thrust "X". However, in structural panels exposed east of thrust "X", members, many cycles, and even single beds are laterally continuous for over 200 km along strike (see Fig. 10.3).

Basal Member

The Basal member is the thickest (100-500 m) and most complex. Its base coincides with the base of the Rocknest Formation which is marked by the first metre-thick bed of dolomite above the highest green shale and siltstone of the Odjick Formation. This basal bed contains discrete or coalesced bioherms of small digitate stromatolites that branch divergently (Fig. 10.4a). The bulk of the member is characterized by shoaling-upward, argillaceous dololutite-to-stromatolitic dolomite cycles. Stromatolites at tops of cycles in the lower part of the member are commonly linked hemispheroids, contiguous or isolated, but tops of cycles in the upper part of the member are capped by dark, cherty, cryptalgal tufa sheets that often contain microdigitate stromatolites (Fig. 10.4b). The uppermost two cycles of the Basal member have **Conophyton** bioherms (Fig. 10.4c) except in the thrust sheet to the east of thrust "X", and in the northeastern corner of the autochthon. The same two cycles can be recognized in most areas, making them very reliable stratigraphic markers. The contact between the top of the upper **Conophyton**-bearing cycle and the base of the succeeding cycle is used as the boundary between the Basal member and the overlying Lower Shale member, and as one boundary in a three-fold subdivision of the Rocknest Formation on 1:250 000 scale maps.

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Lower Shale Member, 30-80 m thick

The lower part of the Lower Shale member comprises shale-dominated cycles with thin cryptalgalaminite caps. Upwards in the member, cycles are more stromatolitic and the uppermost cycles are dominated by dark, cherty, cryptalgal tufa with microdigitate stromatolites. The boundary between the Lower Shale member and overlying Intraclastic member coincides with the contact between the uppermost of these cycles and the lowest cycle of the Intraclastic member.

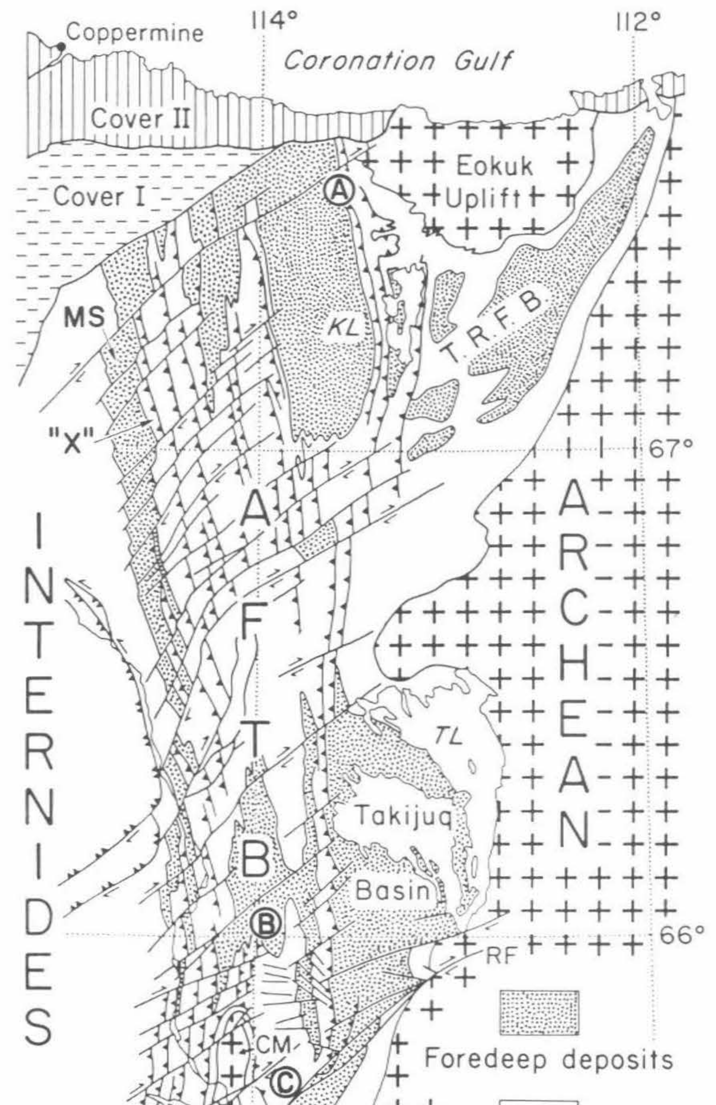


Figure 10.1. The externides of Wopmay Orogen showing location of syncline "M" (MS), thrust "X" ("X"), and measured sections (A, B, C) of Figures 10.2 and 10.3. AFTB, Asiak Fold-Thrust Belt; TRFB, Tree River Fold Belt; CM, Carousel Massif; RF, Redrock Fault; KL, Kikerk Lake; TL, Takijuq Lake; RL, Redrock Lake; PL, Point Lake. Adapted from Hoffman et al. (1983, Fig. 60.1).

Intraclastic Member, 20-100 m thick

The lowest cycle of the Intraclastic member has argillaceous dololutite that passes upwards into a very distinct, laterally continuous bed of dolomitic, isolated, columnar stromatolites with furcate branching. This bed is sharply overlain by a noncyclic interval of dolomitic, partially linked, strongly elongate, pseudocolumnar stromatolites. The lower part of the member passes gradationally upwards into dolomitic, crossbedded intraclast grainstone/packstone that generally fines upwards into planebedded to crossbedded dolarenite grainstone/packstone with interbeds of dolomitic, crossbedded intraclast grainstone/packstone. The top of the Intraclastic member is gradational with the base of the Thrombolitic member and the boundary is placed at the base of the first argillaceous or stromatolitic bed above the uppermost metre-thick bed of intraclast grainstone/packstone.

Thrombolitic Member, 50-110 m thick

The Thrombolitic member comprises at least 17 cycles, several of which contain very distinctive stromatolite and thrombolite (Fig. 10.4d) beds that make superb markers for testing the potential of long distance cycle correlation (Fig. 10.3). In particular, a light, cherty, **Conophyton**-bearing bed occurs just below the upper boundary of the member, which is placed at the base of the first metre-thick interval containing cream, crosslaminated dolosiltite and dolarenite grainstone with nodular white chert. This boundary is also used for 1:250 000 scale maps.

Pink Chert Member, 10-70 m thick

The Pink Chert member contains interstratified sequences of very distinctive reddish-pink dolosiltite with nodular pink chert, and cream, crosslaminated dolosiltite and dolarenite (ooid-intraclast) packstone. Both lithologies exhibit wave-ripple crosslaminae draped by cryptalgalaminite. The upper boundary of the Pink Chert member is placed at the base of the lowest metre-thick interval of argillaceous dololutite above the uppermost cream dolosiltite with nodular white chert.

Domal Stromatolite Member, 30-100 m thick

The base of this member has one or two cycles dominated by thick intervals of argillaceous dololutite that pass upward into thin cryptalgalaminite caps containing uncommon domal stromatolites. These first cycles are succeeded by stromatolite-dominated cycles containing abundant linked, very closely spaced domes, and cycle caps with dark, cherty cryptalgal tufa sheets that often contain microdigitate stromatolites. Although stromatolite-dominated cycles are typical of the middle and upper parts of the member, bases of cycles in the middle part of the member frequently contain argillaceous dololutite which is uncommon at bases of cycles in the upper part of the member. The upper boundary of the Domal Stromatolite member occurs at the top of the uppermost cycle containing stromatolites below the lowest metre-thick interval of argillaceous dololutite.

Red Shale Member, 20-100 m thick

The Red Shale member consists entirely of argillaceous dololutite and dolosiltite, with intercalated beds of intraclast packstone, intraclast/ooid packstone, and dolarenite packstone with large intraclast rip-ups. Wavy cryptalgalaminite also occurs at the tops of shale-dominated cycles. The top of this member grades into the overlying Thin member and the boundary is at the top of the lowest stromatolitic bed that is succeeded by several argillaceous dololutite-to-stromatolitic dolomite cycles.

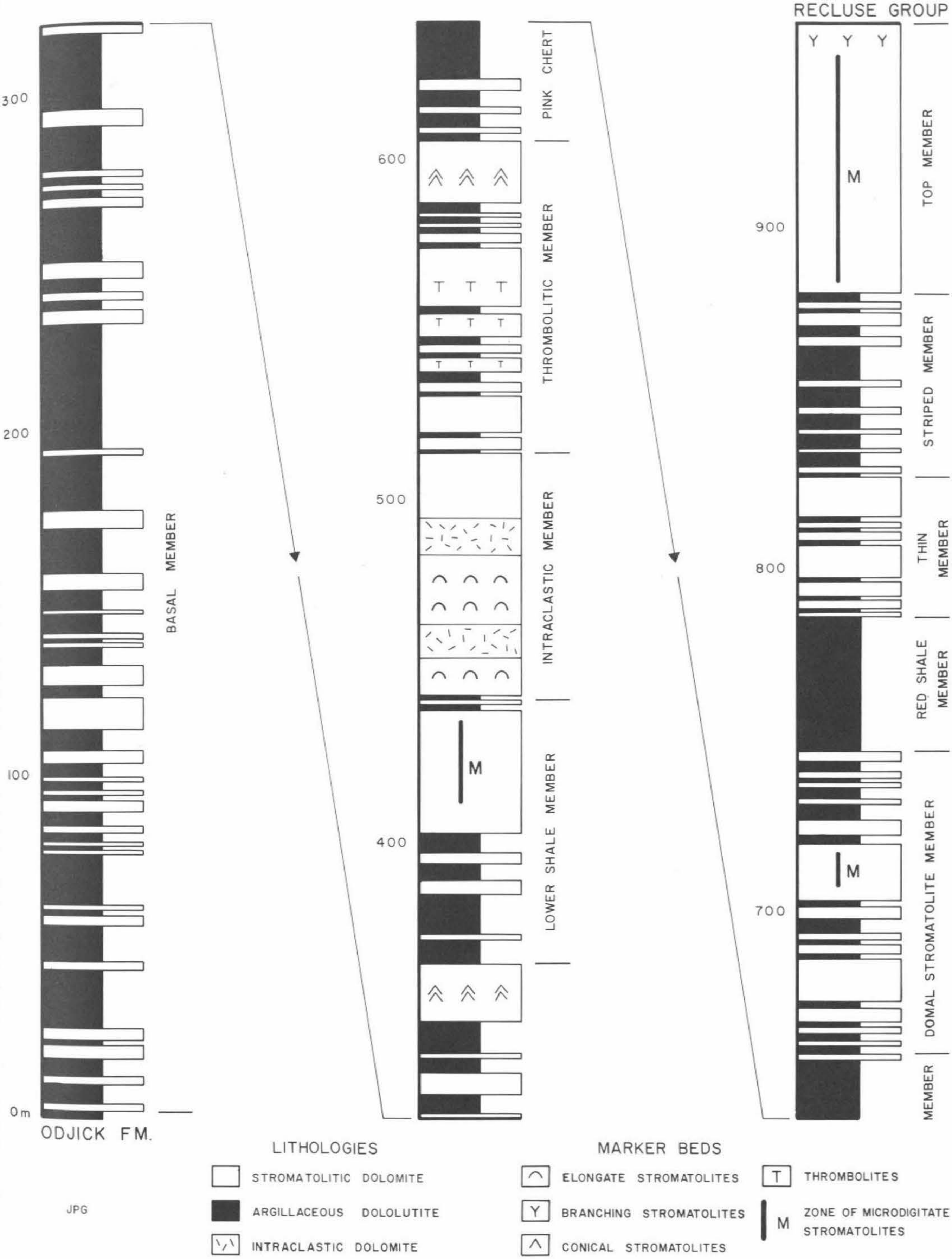


Figure 10.2. *The ten informal members of the Rocknest Formation, section (A), northern Asiak Fold-Thrust Belt.*

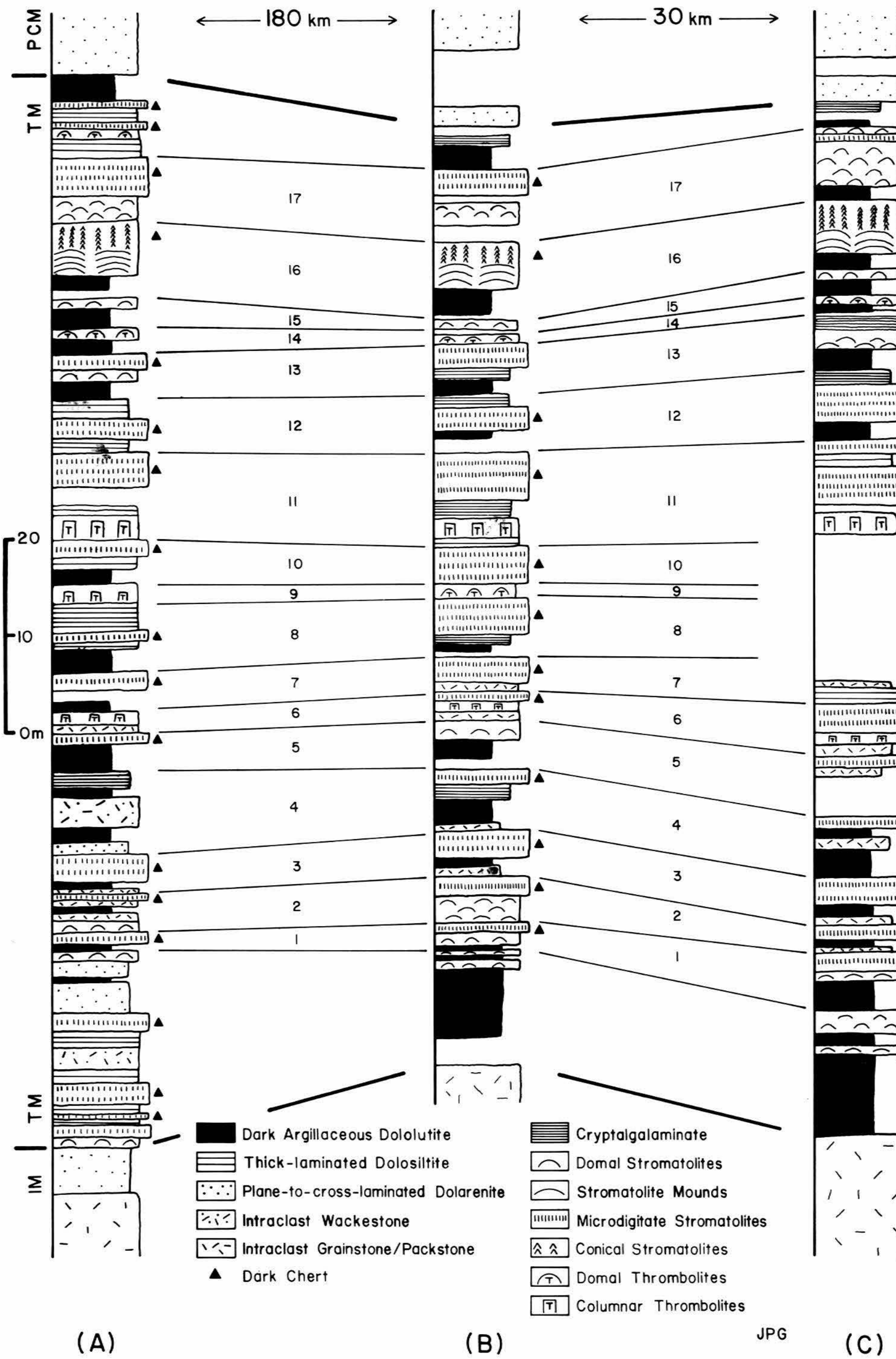


Figure 10.3. *Correlation of 17 cycles in Thrombolitic member (TM). IM, Intraclastic member; PCM, Pink Chert member. Location of sections shown in Figure 10.1.*

Thin Member, 10-30 m thick

The lower part of the Thin member comprises several cycles which become progressively more stromatolite-dominated toward the upper part of the member. The cycle caps in the upper part of the member frequently have cherty, cryptalgal tufa sheets with uncommon microdigitate stromatolites. Locally, these uppermost cycles also contain the columnar stromatolite **Conophyton** that passes upwards into **Baicalia**-like stromatolites, or less commonly, branching conical stromatolites resembling **Jacutophyton** that pass up into **Baicalia**-like stromatolites. These cycles resemble those described by Serebryakov (1976), and Jackson (1982). The upper boundary of the Thin member is placed at the top of the uppermost sequence of stromatolite-dominated cycles below the lowest metre-thick interval of argillaceous dololutite of the overlying Striped member.

Striped Member, 30-70 m thick

The lower part of the Striped member comprises shale-dominated cycles with intercalated beds of intraclast packstone and intraclast/ooid packstone. Cycle caps are relatively thin and stromatolitic. Upwards, cycles become stromatolite-dominated and the upper boundary of the Striped member is placed at the top of the uppermost cycle containing over 0.5 m of argillaceous dololutite.

Top Member, 60-150 m thick

The Top member is mostly stromatolitic except for a few beds of argillaceous dololutite in cycles at the base of the member. The member typically comprises a large number of cycles that contain small, linked to unlinked stromatolites at bases that pass upward into dark, cryptalgal tufa sheets that characteristically are not cherty, in contrast to the cryptalgal tufa sheets found in other members below. Furthermore, in many locations the cryptalgal tufa sheets dominate cycles and it becomes difficult to identify successive cycles, which may consist entirely of amalgamated cryptalgal tufa sheets. The upper part of this member is very distinct. It consists of several successive biostromes containing a diverse assemblage of branching columnar stromatolites that bear a resemblance to such forms including **Gymnosolen**, **Minjaria** and **Tungussia**. Although this interval of columnar stromatolites is present in every structural panel which exposes the Rocknest Formation except for the "X" thrust sheet, stromatolite forms in the biostromes vary considerably both vertically on the scale of a metre or two, and laterally on the scale of tens of kilometres. The upper boundary of the Top member coincides with the top of the Rocknest Formation which conformably underlies the Tree River Formation everywhere except in the northeastern corner of the autochthon where the contact is an erosional disconformity. Typically, the uppermost metre or two of stromatolitic dolomite contains small lenses of quartzose sandstone and siltstone which are developed between stromatolite columns. Above this zone, siliciclastic sediments blanket the carbonates and the upper boundary is placed at the top of the uppermost stromatolite bed.

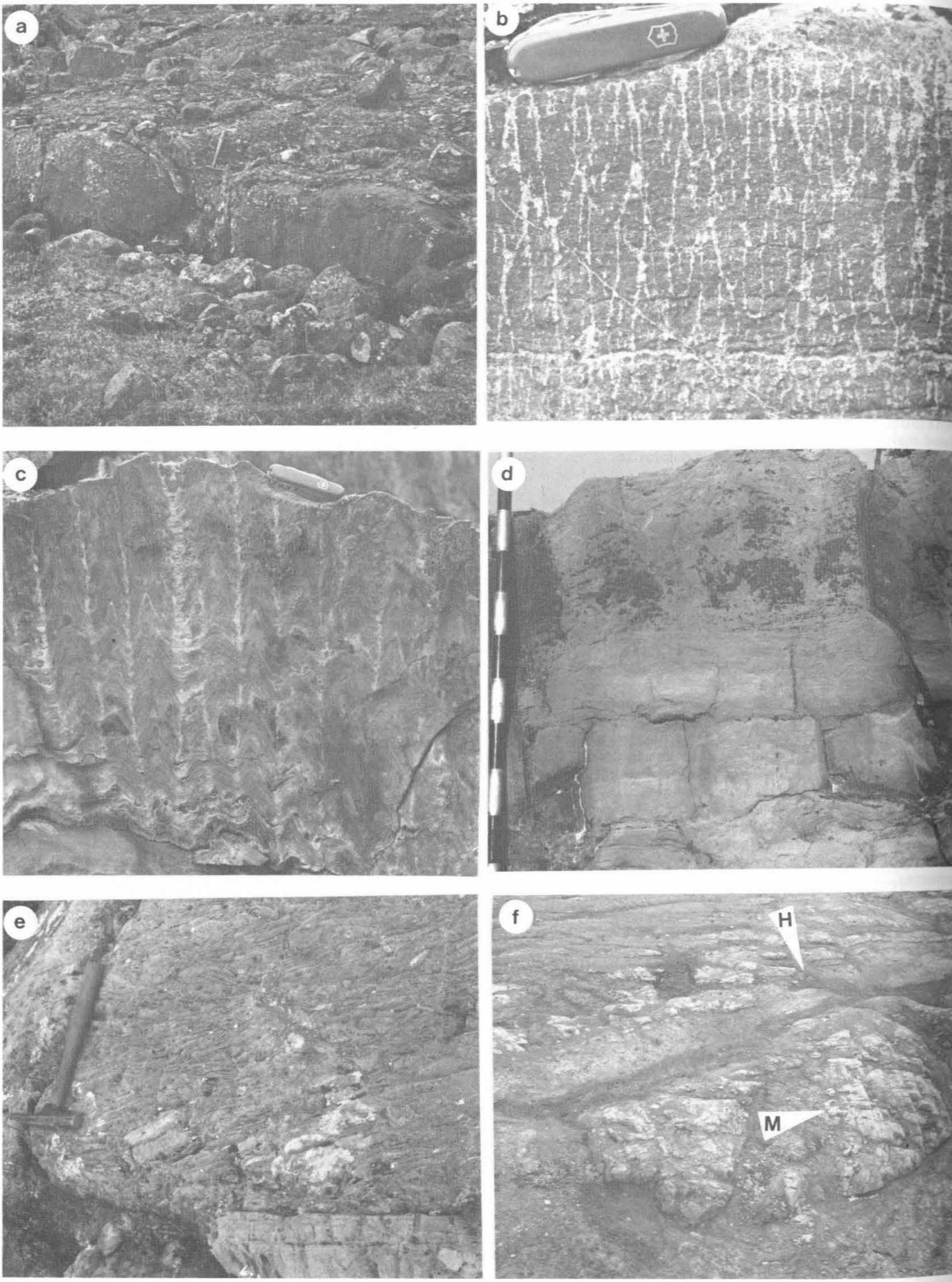
Rocknest Shelf Cyclicity and Paleogeography

The asymmetric, shoaling-upward cycles of the Rocknest Formation have been described and interpreted by Hoffman (1975). Here, their relationship to the members is briefly discussed and analyzed from the standpoint of the implications this relationship may have for evaluating longer term variations in sea level during Rocknest deposition, and reconstructions of Rocknest shelf paleogeography.

The cycles comprise asymmetric, argillaceous dololutite-to-stromatolitic dolomite sequences, 1-10 m thick, and represent the progradation of stromatolitic tidal flats across muddy lagoons (Hoffman, 1975). They have striking lateral continuity; the 17 cycles of the thrombolitic member can be traced for over 200 km parallel to depositional strike (see Fig. 10.1, 10.3). The continuity of cycles across depositional strike has not yet been tested and may provide the key for understanding the mechanism of cyclicity. The cycles are typical of all members in the Rocknest Formation, except for the Intraclastic member, in which cycles have not been recognized, if present. A cycle with the complete range of component facies contains: 1) basal transgressive intraclastic lag lying on and derived from the top of preceding cycle, overlain by 2) reddish or greenish argillaceous dololutite with wave ripples, salt casts and synaeresis cracks, overlain by 3) thickly laminated tan dolosiltite and edgewise conglomerate, overlain by 4) stromatolitic or thrombolitic dolomite boundstone in which synoptic relief decreases upwards, overlain by 5) cryptalgalaminite with salt casts and rare gypsum casts, overlain by 6) dark, cherty, cryptalgal tufa with microdigitate stromatolites, salt casts, and rare gypsum casts. It is important to note that this is not an "ideal cycle" and the application of such an abstraction to cycle analysis should be avoided. A cycle with all the components listed above may be typically found within the Domal Stromatolite member or the Thrombolitic member, but is not typical of the Red Shale member or Top member which may, respectively, contain cycles that have no stromatolitic tops or argillaceous bases. Instead, a more useful concept for cycle analysis and classification utilizes end-members. Between end-members, development of component facies ranges from shale-dominated in which stromatolitic tops may be poorly developed or absent, to stromatolite-dominated in which shale bases may be poorly developed or absent. An intermediate cycle has all six component facies and represents rapid submergence of the shelf, followed by progradation and shoaling to sea level. Accordingly, shale-dominated cycles represent complete submergence of the shelf followed by incomplete shoaling to sea level before the next submergence increment, and stromatolite-dominated cycles represent incomplete submergence of the shelf followed by complete shoaling to sea level. These relationships indicate that complete shoaling of the shelf to sea level was not required to induce the next submergence increment, suggesting that the mechanism involved was allocyclic rather than autocyclic.

The transition from one member to the next is marked by a change in the ratio of lower components to upper components in cycles. For example, the transition from the Red Shale member to the Thin member is characterized by the gradual appearance of upper components and disappearance of lower components within a set of successive cycles. The top of the first cycle in which a stromatolitic bed occurs provides the upper boundary for the Red Shale member. These transitions from members in which cycles are dominated by the lower components (e.g. Red Shale member) to members in which cycles are dominated by the upper components (e.g. Thin member) constitute the basis for defining longer term variations in relative sea level on the Rocknest shelf. It is suggested that members containing primarily shale-dominated cycles represent times when relative sea level was higher over the platform-interior, in contrast with members containing primarily stromatolite-dominated cycles that were deposited during times when the platform was aggraded and relative sea level was very low.

Data collected during the 1981 and 1982 field seasons suggest that the Rocknest shelf had three north-trending facies belts, approximately parallel to structural strike; a western reefal rim and peritidal flat complex, a central fine


a
b
c
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M

grained mixed terrigenous/carbonate lagoonal belt, and an eastern terrigenous clastic-dominated shoreline paralleling the exposed craton. The eastern clastic shoreline may be represented by terrigenous sediments in the upper Western River Formation or overlying Burnside River Formation (Goulburn Group, Kilohigok Basin), exposed near Rockinghorse Lake and Contwoyto Lake, 30-100 km east of the preserved Rocknest platform. Furthermore, the cycles most likely formed by west to east progradation of tidal flats from the reefal rim toward the centrally located lagoon. This hypothesis will be tested during the 1983 field season by conducting detailed studies of facies changes within cycles across depositional strike. Features that would support the suggested paleogeographic configuration include 1) evidence of westward stratigraphic thinning, or pinch-out of argillaceous dololutite (lagoonal facies) within cycles, indicating a centrally located lagoon, and 2) lateral transition of argillaceous dololutite to more siliciclastic-rich and coarser grained sediments to the east, indicating a clastic-dominated shoreline to the east of the lagoon. If valid, the hypothesis predicts that the reefal rim and peritidal flat complex should have been narrowest during periods of shale-dominated cyclic deposition (e.g. Red Shale member), and broadest during periods of stromatolite-dominated cyclic deposition (e.g. Top member). Such a paleogeographic configuration is similar to that proposed for the Cambrian of the Canadian Cordillera (Aitken, 1978).

Shelf-to-slope Transitions

Facies

The exposed shelf-edge and slope facies of the Rocknest Formation occur exclusively in the syncline "M" (Fig. 10.1) where the west limb exposes down-slope facies, and the east limb exposes both shelf-edge and up-slope facies. Shelf-edge reefal facies are characterized by algal boundstone sheets composed of strongly elongate, partially linked mounds with up to 2 m of synoptic relief. Channel deposits composed of trough crossbedded intraclast/ooid grainstone are locally well developed, but generally uncommon indicating that the stromatolite reefal rim was a very continuous, wave resistant structure.

Back-reef facies comprise thick, laterally continuous sheet-like bodies of crossbedded intraclast/ooid grainstone and low relief, strongly elongate, partially linked stromatolites. Locally, back-reef facies are overlain by peritidal facies containing spectacular examples of tepee antiform structures up to 1 m in width. The tepees contain giant silica and dolomite pseudomorphs of botryoidal aragonite that are attached to, and diverge downwards from the undersides of buckled plates (Grotzinger and Read, in press; Hoffman et al., 1983, Fig. 60-2).

Reefal-foreslope deposits are characterized by very thinly bedded, graded dolarenite/dolosiltite rhythmites with intercalated, flat-bottomed lensoidal bodies of vertically packed intraclasts. These sequences are associated with large **Conophyton** bioherms in which individual cones may have up to 1 m of synoptic relief. Locally, the bioherms contain isolated, branching **Conophyton** stromatolites resembling **Jacutophyton.** These deposits are very similar to those described by Hoffman (1974) for similar depositional settings in the Pethei Group of Athapuscow Aulacogen.

Upper-slope facies comprise thick sequences of graded, thickly laminated dolarenite and dolosiltite rhythmite with massive or laminated dololutite. Locally these deposits exhibit large-scale slump folding associated with concave-up slump scars and brecciated rhythmites. Breccia units may also be developed independently(?) of slumping as isolated lenses containing platy rhythmite clasts within otherwise undisturbed rhythmite. Breccias containing clasts derived from the shelf-edge do not occur as part of the upper-slope facies.

Lower-slope facies are restricted to a very thin panel, usually less than 100 m thick, on the west limb of syncline "M" where they are characterized by abundant resedimented platy rhythmite breccia units which commonly contain shelf-derived talus blocks. Individual breccia units generally fine upward and are amalgamated, or separated by thinly laminated dolosiltite/dololutite beds. Internally, the clasts are both matrix and self supported, and are oriented parallel to bedding although they are locally imbricated in an upslope direction (Fig. 10.4e). These deposits are similar to debris flows described by Cook and Taylor (1977) and probably have a similar origin.

West of syncline "M" the Recluse Group directly overlies the Odjick Formation indicating a stratigraphic pinch-out of the Rocknest Formation. At that location the Odjick Formation is of continental rise facies (Hoffman, 1973) indicating substantial water depth. The pinch-out of the Rocknest Formation can be explained by either nondeposition due to sediment starvation farther up on the slope, dissolution of sediment below the carbonate compensation depth, or a combination of both. Although the level of the carbonate compensation depth during Rocknest deposition cannot be evaluated, it seems reasonable to assume that carbonate dissolution may not have been important because of the preservation of periplatform talus aprons down to depths of several kilometres adjacent to modern carbonate platforms (Bathurst, 1975; Mullins and Neumann, 1979). More likely, sediment starvation had the greatest effect on the ultimate thickness of sediment deposited on the Rocknest slope and on the position of the stratigraphic pinch-out. Sediment starvation was probably related to local drowning and backstepping of the reefal rim during evolution of the shelf-edge (see below), and to the landward sediment transport effect of likely onshore directed paleotradewinds (Hoffman et al., 1983) during Rocknest deposition.

Relationship of Shelf-Edge to Structure

For most of the distance along syncline "M", the Rocknest shelf-to-slope transition occurs between its east and west limbs. Because of this coincidence between structural strike of syncline "M" and trend of the Rocknest facies change, it is inferred that the strike of the syncline is parallel to the general trend of the shelf-edge. However, locally along strike in the eastern panel, upper-slope facies

***Figure** 10.4. (opposite)*

a. *Discrete bioherms of digitate stromatolites in basal bed of Rocknest Formation.*

b. *Microdigitate stromatolites.*

c. ***Conophyton.***

d. *Partially linked columnar thrombolites in cycle 6, Thrombolitic member, section (B). Dark where cryptalgal "clots" are selectively silicified, imparting a splotchy appearance to the bed. Thrombolites overlie intraclast grainstone/packstone (middle of figure), and domal stromatolites (bottom of figure). Jacobs staff marked in decimetre intervals.*

e. *Resedimented, platy rhythmite breccia sharply overlying undisturbed rhythmite, west limb of syncline "M". Clasts are imbricated upslope.*

f. *Megabreccia block (M), east limb of syncline "M". Stratigraphic facing (arrow) of host sediments (H) is from top left to bottom right; in block, from centre to centre right. Block is approximately 50 m wide.*

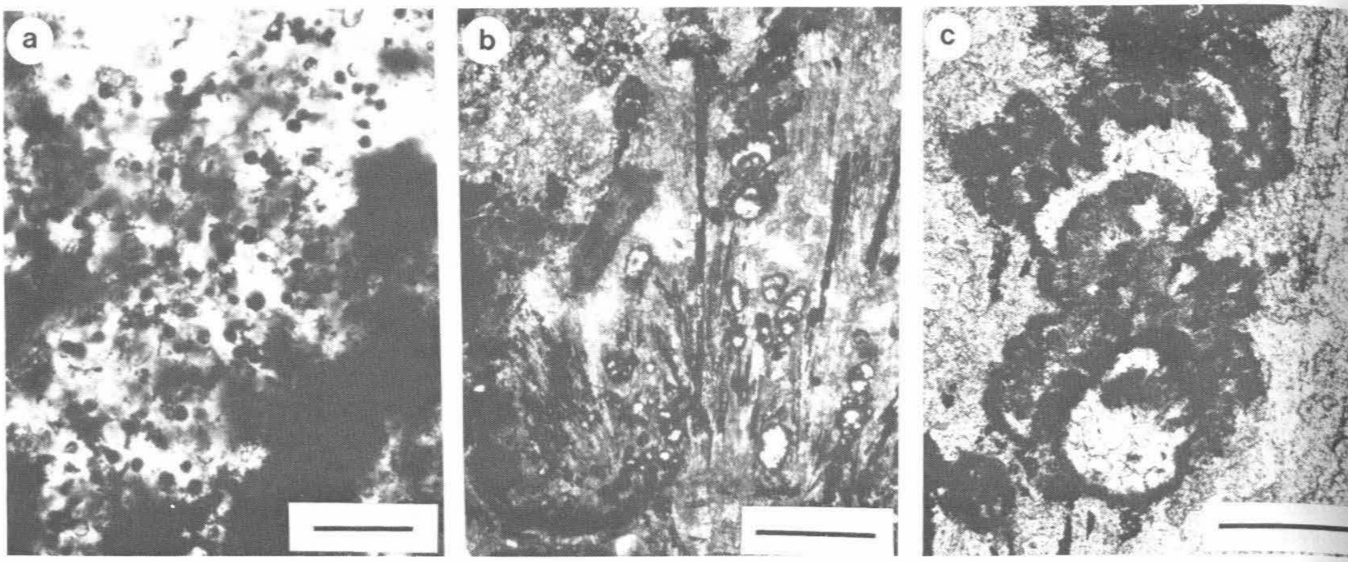

Figure 10.5.

a. *Thin section photomicrograph of microbial(?) spheres and filaments in dolomitized aragonite marine cement, Odjick/Rocknest transition beds. Scale bar is 10 microns.*

b. *Thin section photomicrograph of fibrous dolomite neospar after upward divergent, botryoidal aragonite cement. Precursor fibres (prominent, weakly divergent vertical fabric) are outlined by thin hematitic coatings and inclusion trains. Note the* ***Renalcid****-like microcolumnar structures. Scale bar is 3 mm.*

c. *Thin section photomicrograph of* ***Renalcid****-like microcolumnar structure with superimposed, upward-branching inflated chambers. Hematitic coatings outline chambers which are enclosed in turbid dolomite neospar, and filled with clear dolomite neospar. Scale bar is 1 mm.*

are exposed rather than shelf-edge facies. This variation in the distribution of upper-slope facies versus shelf-edge facies along the eastern limb of syncline "M" could be explained by either of the following: 1) the shelf had an irregular margin with promontories coinciding with areas of preserved shelf-edge facies and embayments coinciding with areas of preserved upper-slope facies, or 2) the distribution of facies is structurally controlled. Even though the former explanation seems possible by analogy with modern rimmed shelves which are known to be irregular (Maxwell, 1968; Purdy et al., 1975), the latter explanation is more likely for this case. Facies changes along the east limb of syncline "M" occur over transcurrent faults which postdate and segment the syncline. Although they are dominantly strike-slip faults, a small component of dip-slip (up to 200 m) can be demonstrated for some areas with good stratigraphic control (Tirrul, personal communication, 1983). Since the dip of the Rocknest Formation on the east limb of syncline "M" is generally 60 degrees west, a dip-slip component of 200 m on a transcurrent fault would produce a 240 m separation of the Rocknest Formation perpendicular to the shelf-edge. In syncline "M", upthrown blocks would tend to show more seaward facies relative to downthrown blocks which would tend to show more landward facies. In Holocene reefal rims, facies changes are very abrupt between the reefal rim and upper slope and often occur on the order of tens to hundreds of metres (Longman, 1981). Thus, vertical offsets along transcurrent faults could account for the observed distribution of facies along strike in the east limb of syncline "M".

Evolution of Shelf-Edge

Along the east limb of syncline "M", the Rocknest Formation shows several general features of shelf-edge evolution. In the early stages of rim development, reefal facies prograded out over upper-slope carbonates and upper-slope clastics of the underlying Odjick Formation. This was followed by the progradation of back-reef facies and peritidal facies over reefal facies. Subsequent to the initial stage of progradation, the shelf-edge entered a period of aggradation during which a reefal rim was established and vertically built up as shown by the uninterrupted deposition of up to 600 m of shelf-edge sediments. Progradation and aggradation of the rim was recorded downslope by deposition of only 200 m of rhythmite and slope/shelf-edge breccias on argillaceous siltstones of the Odjick Formation, preserved in the west limb of syncline "M".

At the end of this stage of shelf-edge development, construction was interrupted and terminated along the length of the margin as shown by the abrupt deposition of thinly laminated dololutite and black shale over reefal facies. This event of shelf-edge drowning occurred locally and was associated with backstepping of the reefal rim to a position not exposed, but which must lie palinspastically between the present outcrop on the east limb of syncline "M", and the outcrop of the next thrust sheet to the east where there is no evidence for drowning and the Rocknest Formation attains its greatest thickness of over 1 km.

After backstepping, the reefal rim began another aggradational phase that persisted until the terminal drowning of the entire platform. During this stage a steep escarpment was constructed as shown by the occurrence of huge, allochthonous shelf-edge derived blocks up to 40 m in length that fell onto the earlier drowned rim (see Fig. 10.4f). More commonly, drowned rim deposits are overlain by thickly laminated, graded rhythmites and resedimented rhythmite breccias containing shelf-edge derived talus blocks. The drowned rim was a terrace that acted as a trap and probably prevented most sediment from being transported over its edge and down the main slope into the basin, thus starving the main slope of sediment. This interpretation is supported by the very thin section of slope deposits in the west limb of syncline "M", which contains an upper starved-slope unit of laminated dololutite (10-20 m thick) that sharply overlies a lower unit (100 m) of graded rhythmites and platy rhythmite breccias containing shelf-edge derived talus blocks. The lower unit was probably deposited during upbuilding of the older, drowned rim; the upper unit was probably deposited as "background" sediment during upbuilding of the younger, backstepped rim. The main slope must have been a zone of bypassing during upbuilding of the older rim as shown by the occurrence of shelf-edge derived blocks in down-slope deposits of the west limb of syncline "M", which are not present in up-slope deposits of the east limb. At the time of rim backstepping, the average inclination of the slope was probably 4-7 degrees (Hoffman et al., 1983).

In general, evolution of the Rocknest shelf margin was very similar to the evolution of Phanerozoic rimmed shelves, involving stages of progradation, aggradation, backstepping, and drowning (Read, 1982). The principles involved behind the evolution of the Rocknest platform margin may have been similar to those operative on the modern margin of the Bahamas where similar features are currently being produced (Schlager and Camber, 1982).

Paleoclimate

The Rocknest Formation was previously interpreted to have been deposited in a humid paleoclimatic setting (Hoffman, 1975). This interpretation was based in part on comparison of Rocknest cryptalgal tufas and microdigitate stromatolites at the tops of shoaling-upward cycles with algal tufa crusts currently being formed in fresh/brackish water supratidal ponds on Andros Island, Bahamas. Hoffman (1975) noted that Rocknest cryptalgal tufas, like Bahamian algal tufas, most likely formed by direct precipitation of carbonate in algal mats and cited the development of palisade structure with preserved filament molds as evidence for this. However, additional field and petrographic studies have recently shown that the most likely carbonate cement precipitated in Rocknest cryptalgal tufas was not calcite (predicted for humid climate), but dolomitized aragonite (predicted for semiarid to arid climate). Evidence for aragonite precipitation in Rocknest cryptalgal tufas includes square and feathery terminations of precursor acicular crystals, replaced by neospar mosaics containing anhedral, randomly oriented (optically) dolomite crystals with ragged boundaries and abundant inclusions (Grotzinger and Read, in press). In regard of this new information, the Rocknest cryptalgal tufas are reinterpreted to have formed by the direct precipitation (biologically influenced?) of aragonite to form lithified crusts on tidal flats, under semiarid climatic conditions. More evidence for a semiarid setting is discussed below and includes preservation of abundant pseudomorphs after halite, rare pseudomorphs after gypsum and possibly anhydrite, vadose pisolites associated with laminated scalloped surfaces, and tepee structures filled with pseudomorphs after botryoidal aragonite.

Pseudomorphs after halite are common within peritidal cyclic sediments of the Rocknest Formation. They are best preserved as displacive cubic crystal casts in "detrital" carbonate mud interlaminae of cryptalgal tufas in the upper parts of cycles, and as skeletal hopper casts in argillaceous dololutites in lower parts of cycles. Less commonly, displacive halite casts occur in muddy layers of stromatolitic facies within cycles. Displacive halite casts in cryptalgal tufas are 0.05-3.0 mm wide and filled with muddy host sediment or early diagenetic chert. Skeletal hopper crystal casts in argillaceous dololutites are up to 5 cm wide and show no evidence of silica replacement. In both cases, crystal faces tend to be oriented subparallel to bedding. In contrast to the abundance of halite casts, crystal casts after gypsum or anhydrite are rare. However, well preserved swallow-tail, rosette cluster, and lozenge-shaped casts after gypsum occur in a few cycles capped by cryptalgal tufa sheets. These pseudomorphs are now preserved as coarse, brown ankeritic dolomite, which similarly fills associated globular masses that may have been anhydrite.

Other features in the Rocknest Formation that are diagnostic of semiarid climates are tepee structures, vadose pisolites associated with cryptalgal tufas, and inorganic cement crusts on scalloped surfaces (Purser and Loreau, 1973; Scholle and Kinsman, 1974; Assereto and Kendall, 1977). Tepee structures in the Rocknest Formation occur in back-reef peritidal and cyclic peritidal settings. Those of back-reef peritidal origin are large (up to 1 m) and locally filled with silica and dolomite pseudomorphs after downward-diverging botryoidal aragonite (Grotzinger and Read, in press); tepees found in cyclic peritidal settings are small (up to 20 cm) and occur in cryptalgal tufa sheets at tops of cycles, associated with broken plates of cryptalgal tufa that are coated by later generations of tufa. Less commonly, these features are associated with scalloped surfaces, outlined by finely laminated fibrous cement, and filled with irregular-shaped pisolites. These pisolite-filled surfaces are overlain by isopachous linings of additional laminated, fibrous cement.

Possible Microfossils in the Odjick/Rocknest Transition Beds

Well preserved microbial remnants(?) occur in dolomite/hematite stromatolite bioherms of the Odjick/Rocknest transition beds. Bioherms (up to 30 cm thick) are lenticular units (50 cm x 10 m) enclosed within green and red shales, siltstones and pebbly sandstones. The siliciclastic sediments contain crossbedding, hummocky storm deposits, lenticular channel deposits, and lack desiccation features suggesting deposition on a subtidal, shallow shelf. Stromatolitic layers in bioherms are flat, irregular to wavy, and locally form low, sharp-crested peaks with 1-4 mm relief. In plan, stromatolites are 1-5 cm long, and strongly elongate. Laminae are 0.01-0.1 mm thick and consist of alternating layers or mixtures of dolomite and hematite. Some layers contain detrital, rounded quartz grains (up to 2.5 mm) and rare dolomite intraclasts.

Stromatolitic layers are interbedded with and pass laterally into layers of noemorphic, acicular carbonate characterized by mosaics of anhedral, turbid, randomly oriented (optically) dolomite crystals with ragged boundaries. Acicular cement fans contain well preserved precursor crystal fibres of aragonite that are outlined by very thin synsedimentary hematite coatings and inclusions (Fig. 10.5b). The possible microfossils occur within dolomite neospar cement layers; well preserved forms include spheres (2-20 microns) and filaments (1-2 microns wide, 4-20 long) outlined by hematite (Fig. 10.5a), and questionable microcolumnar structures made of upward-branching inflated chambers (Fig. 10.5b,c) that resemble the Paleozoic alga **Renalcis.** Microcolumnar structures are 0.2-4.0 mm tall and 0.06-0.9 mm wide; component chambers are 0.08-0.24 mm high and 0.06-0.9 mm wide, with walls 0.016-0.026 mm thick. Walls often have isopachous, extremely fine, fibrous fringes on their outer sides and show no obvious pigmentation gradients. Spheres and filaments are not usually associated with microcolumnar structures, and typically occur as geopetal "sediment" in primary voids within stromatolitic layers, now filled with neomorphic dolomite cement. Filaments appear to have been torn and eroded from stromatolitic laminae. Spheres may also have been a component of the stromatolitic laminae, although this is less certain.

Future Work

The final season for field study of the Rocknest Formation is planned for 1983. Investigations will focus on detailed studies of the complex reefal rim and flanking facies belts, and on east-west facies changes within the cycles at the northern end of the thrust-fold belt.

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